XIV. *A Paper to obviate ſome Doubts concerning the great Magnifying Powers uſed. By Mr.* Herſchel, *F. R. S.*

TO SIR JOSEPH BANKS, BART. P. R. S.

SIR,

I HAVE the honour of laying before you the reſult of a ſet of meaſures I have taken in order to aſcertain once more the powers of my Newtonian ſeven-feet reflector. The method I have formerly uſed, and which I ſtill prefer to that which I have now been obliged to practiſe, requires very fine weather and a ſtrong ſun-ſhiny day; but my impatience to anſwer the requeſts of Sir JOSEPH BANKS would not permit me to wait for ſo precarious an opportunity at this ſeaſon of the year. The difference in all the powers, as far as 2010, will be found to be in favour of thoſe I have mentioned; and, I believe, a much greater concurrence could not well be expected, where different

different methods of aſcertaining them are uſed. The variation in the two higheſt powers is more conſiderable than I was aware of; but ſtill may eaſily be ſhewn to be a neceſſary conſequence of the difference in the methods. However, if upon comparing together the methods it ſhould be thought, that the power 5786 is nearer the truth than 6450, I ſhall readily join to correct that number. The manner in which I have now determined the powers is as follows: I took one of the eye lenſes which magnifies leaſt, and meaſured its ſolar focus by the ſun's rays as exactly as I could five times, which proved to be 1.01, 1.04, 1.09, 1.01, 1.05, in half-inch meaſure, a mean of which is 1.04. The ſidereal focus of my ſeven-feet ſpeculum is 170.4 in the ſame meaſure. Thence, dividing 170.4 by 1.04 we find that the teleſcope will magnify 163.8 times when that lens is uſed. This power being found, I applied the ſame lens as a ſingle microſcope to view with it a certain object, which was a drawn braſs wire faſtened ſo as not to turn upon its axis or change its poſition; for theſe wires are ſeldom perfectly round, or of an even ſize, and it is therefore neceſſary to uſe this precaution to prevent errors: then, with a fine pair of compaſſes, I took four independent meaſures of the image of the braſs wire, which was thrown upon a ſheet of paper exactly 8½ inches from the lens, the eye being always as cloſe to the lens as poſſible. I viewed the ſame wire, exactly in the ſame manner, with every one of the lenſes, and meaſured the pictures upon the paper. When I came to the higher powers the wire was exchanged for another 4.37 times thinner than the former, as determined by comparing the proportion of their images 54 to 235¾, taken by the ſame lens.

When the images of theſe wires are obtained, the power of the teleſcope, with every one of the lenſes, becomes known by

by one plain analogy: *viz.* as the image of the wire by the firſt lens ($77\frac{3}{4}$) is to the power it gives to the teleſcope (163.8), ſo is the image of the wire by the ſecond lens (119) to the power it will give to the ſame teleſcope (250.7). The particulars of all the meaſures are as follows:

Powers as they have been called in my papers.	Images of a wire thrown upon a paper in hundredths of half inches.				A mean of the four meaſures.	Powers as they come out by this method.
146	77	78	78	78	$77\frac{3}{4}$	$163.86 = \frac{170.4}{1.04}$
227	119	119	119	119	119	250.7
278	143	143	144	143	$143\frac{1}{4}$	301.8
460	236	236	235	236	$235\frac{3}{4}$	496.7
	Smaller wire.					
	53	54	55	54	54	
754	83	85	84	85	$84\frac{1}{4}$	775.1
932	107	107	107	108	$107\frac{1}{4}$	986.7
1159	128	128	129	128	$128\frac{1}{4}$	1179.9
1536	An excellent lens, loſt about eight months ago.					
2010	236	236	238	336	$236\frac{1}{2}$	2175.8
3168	281	283	281	280	$281\frac{1}{4}$	2585.5
6450	635	625	630	626	629	5786.8

I beg leave, Sir, now to give a ſhort deſcription of the method I have formerly uſed to determine theſe powers. In the year 1776 I erected a mark of white paper, exactly half an inch in diameter, which I viewed with my teleſcope at the greateſt convenient diſtance with one of the leaſt magnifiers. An aſſiſtant was placed at rectangles in a field, at the ſame diſtance from

from my eye as the object from the great ſpeculum of the teleſcope. Upon a pole erected there I viewed the magnified image of the half inch, and the aſſiſtant marked it by my direction; this being meaſured gave the power of the inſtrument at once. The power thus obtained was corrected by theory, to reduce it to what it would be upon infinitely diſtant objects. The powers of the reſt of the lenſes I deduced from this by a *Camera-eye-piece*, which I made for that purpoſe. ABCD (fig. 1.) repreſents a perpendicular ſection of it. The end A ſcrews into the teleſcope. Upon the end B may be ſcrewed any of the common ſingle-lens eye-pieces. *lmn* is a ſmall oval plane ſpeculum, adjuſted to an angle of 45° by three ſcrews, two whereof appear at *op*. When the obſerver looks in at B, he may ſee the object projected upon a ſheet of paper on a table placed under the Camera-piece, and meaſure its picture *a*, *b*, as in fig. 2. The power of one lens therefore being known, that of the reſt was alſo found by comparing the meaſures of the projected images.

It may not be amiſs to mention ſome of the advantages and inconveniencies attending each of theſe methods. When we take the focus of an eye-lens, which the firſt method requires, we are liable to a pretty conſiderable uncertainty, and in very ſmall lenſes it is not to be done at all. Moreover, in calculating the power by that focus no account is made of the aberration which takes place in all ſpecula and lenſes, and increaſes the image, ſo that we rather find out how much the teleſcope *ſhould* magnify than how much it really *does* magnify; but in determining the power by an experiment we avoid theſe difficulties.

On the other hand, when the power is very great, the latter method becomes inconvenient, both on account of want of light

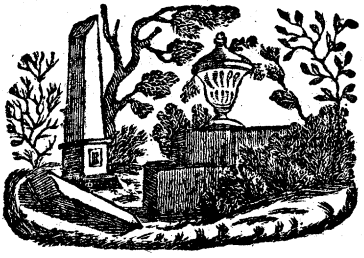
light in the object, and a very conſiderable aberration which takes place, and makes the picture too indiſtinct to be very accurate in the meaſure, and of courſe larger than it ought to be; and this will account for the exceſs in the meaſures of my two largeſt powers. However, when I employed 6450 upon the diameter of α Lyræ, I incline to think the method I had uſed when I determined that power, ought to be preferred, becauſe my Lamp-micrometer gives the meaſure of an object as it appears in the teleſcope, and therefore this aberration is included, and ſhould be taken into conſideration.

To prevent any miſtakes, I wiſh to mention again, that I have all along proceeded *experimentally* in the uſe of my powers, and that I do not mean to ſay I have uſed 6450 (or 5786) upon the planets, or even upon double ſtars; every power I have mentioned is to be underſtood as having been uſed juſt as it is related; but farther inferences ought not as yet to be drawn. For inſtance, my obſervations on ε Bootis mention that I have viewed that ſtar with 2010 (or as in the above table with 2175) extremely diſtinct; but upon ſeveral other celeſtial objects I have found this power of no ſervice. Many plauſible ſuggeſtions have already occurred to account for theſe appearances; but I wait till farther experiments ſhall have furniſhed me with more materials to reaſon upon. The uſe of high powers is a new and untrodden path, and in this attempt variety of new phænomena may be expected, therefore I wiſh not to be in a haſte to make general concluſions. I ſhall not fail to purſue this ſubject, and hope ſoon to be able to attack the celeſtial bodies with a ſtill ſtronger armament, which is now preparing.

It remains now only for me to make the moſt ſincere acknowledgement for the favours you have ſhewn to me, and to ſay that I ſhall ever remain, with equal reſpect and gratitude,

SIR, your moſt obedient, &c.

P. S. Dr. WATSON junior has done me the favour ſeparately to examine and meaſure the powers of my teleſcope; and placing the greateſt confidence in his accuracy, I rely on his meaſures at leaſt as much as my own.



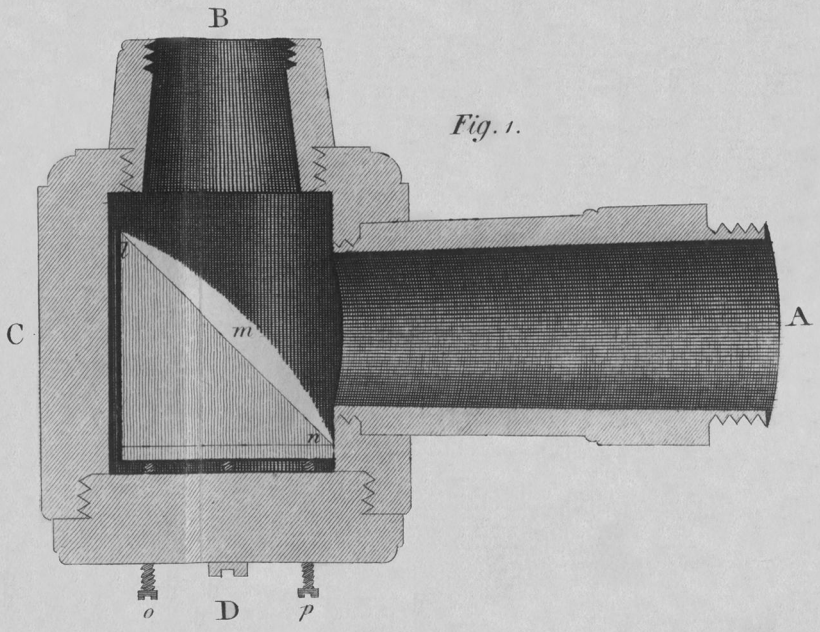


Fig. 1.

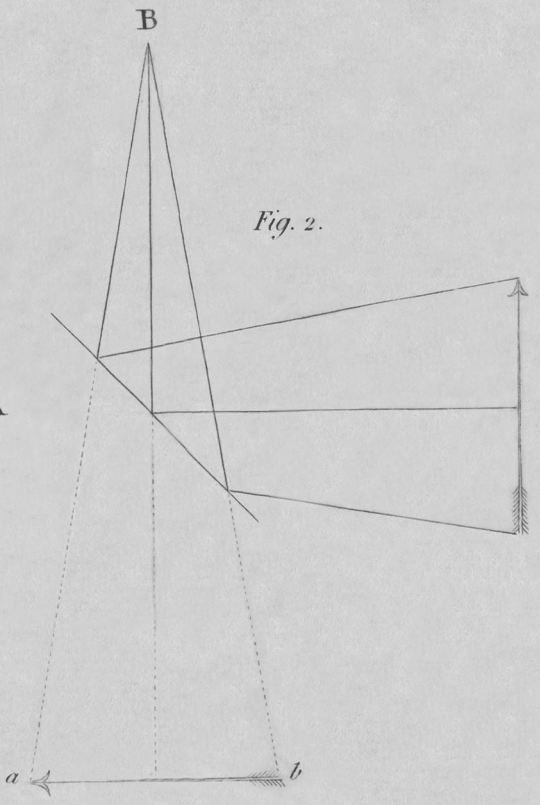


Fig. 2.